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THE TAXONOMY OF THE GENUS *HADRURUS* BASED ON CHELA TRICHOBOTHRIA (SCORPIONIDA: VEJOVIDAE)

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ABSTRACT

Trichobothrial pattern of the chelae provides excellent separation criteria for the major species groups of the genus *Hadrurus*. Trichobothrial nomenclature of *Hadrurus* is established using Vachon's as the basis. Two species groups, the "aztecus" group and the "hirsutus" group, are proposed, where they are further divided into two subgroups each, the "aztecus" and "gertschi" subgroups, and the "hirsutus" and "arizonensis" subgroups. A new species is described from Guerrero, Mexico, *Hadrurus gertschi*, new species where it is compared to the other species of its group, *Hadrurus aztecus* Pocock.

INTRODUCTION

The purpose of this study has been to develop a scheme for differentiating the species of the genus *Hadrurus* (Thorell) using only the chela trichobothria. In preliminary studies presented by Gertsch and Soleglad (1972, p. 564, Figs. 108-112) it was suggested that certain *Hadrurus* species could be separated by internal trichobothria counts on the fixed finger and palm of the chelae. This present work, which is a continuation of that study, shows that major species groups of *Hadrurus* can be differentiated by chela trichobothrial patterns alone. This is significant since the genus *Hadrurus* has been notorious for providing the taxonomist with very few concrete morphological differences for separation criteria at the species level. In the past, heavy reliance has been placed on coloration and its patterns in distinguishing the various species. It is somewhat surprising to find significant trichobothrial pattern differences at the species level. These are not subtle positional differences but involve the presence or absence of accessory trichobothria. During the course of this study a new species, *Hadrurus gertschi,* was originally isolated by trichobothrial analysis. At that time only one female in poor condition was available. As other specimens became available characters other than trichobothria were also isolated as separation criteria.

In 1973 Vachon produced one of the world's most important single works on scorpion systematics. This excellent work presented trichobothrial analysis as a formal discipline, and established a useful and consistent nomenclature. I have at all times tried to stay within Vachon's nomenclature, and more importantly, when applying it have tried to assign correct designations to the individual trichobothrium. However, due to the unusual and complicated patterns found on the genus *Hadrurus*, it has been necessary to

introduce new terms, which hopefully do not conflict too much with Vachon's original nomenclature.

METHODS

Over 200 specimens of the genus *Hadrurus* were studied with respect to the trichobothria of the pedipalpal chelae. All known species and subspecies were studied including a new species. The sampling by species or subspecies, however, was not necessarily evenly distributed, and, in some cases, a somewhat limited number of specimens and/or localities was represented. Table 1 provides information detailing the number of each taxon studied as well as the number of localities represented and their general geographical range. With the possible exception of *H. obscurus* Williams, each species or subspecies was well represented with respect to geographical range. All *H. obscurus* specimens were from Southern California, somewhat south of its recorded range (Williams, 1970, and Hjelle, 1972); the northern most sample came from the southern portion of Joshua Tree National Monument. The other specimens sampled were from the Anza-Borrego State Park or further south, approaching the Mexican border. The basic verification of chela trichobothrial patterns for each species involved all the specimens enumerated in Table 1. This includes counts of the internal and external accessory, and ventral trichobothria. The ratios, however, were selected from a much smaller set of species and specimens, assuring that adults were used in their calculation. Table 3 provides the number of specimens used in the ratio calculations. The counts were established from

Table 1.–*Hadrurus* specimens sampled.

	Number of Specimens Sampled	Number of Localities Represented	General Geographical Range of Samples
H. aztecus	12	2	Puebla and Oaxaca
H. gertschi	7	3	Guerrero
H. hirsutus	8	2	Baja, Sur (Cabo San Lucas)
H. concolorous	16	7	Baja, Norte and Sur (Punta Prieta to Los Aripes)
H. pinteri	8	3	Baja, Norte, and Sur (Oakies Landing to San Ignacio)
H. arizonensis	94	12	Arizona, California, Sonora, and Baja, Norte
H. a. arizonensis	58	6	Arizona, California, Sonora (to Guaymas)
H. a. pallidus	34	5	California, Sonora, and Baja, Norte
H. a. austrinus	2	1	Baja, Norte (Oakies Landing)
H. spadix	58	12	Oregon, Idaho, Utah, Arizona, Nevada, and California
H. obscurus	18	5	Southern California

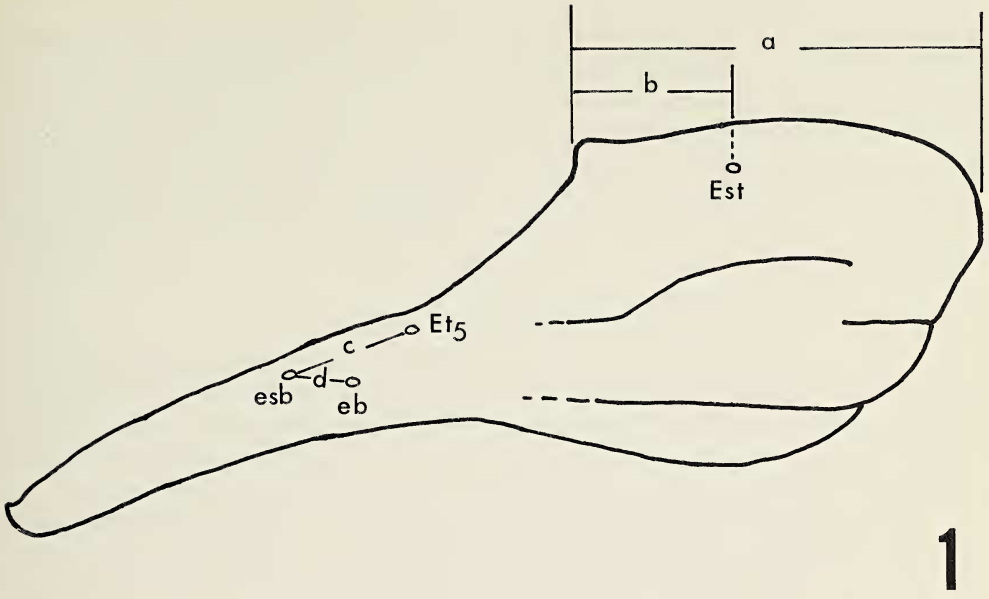


Fig. 1–External view of *Hadrurus* chela, showing methods of measurement. a, palm length; b, distance from *Est* to terminal aspect of palm; c, distance from *Et5* to *esb*; and d, distance from *eb* to *esb*.

both adult and immature specimens. In all cases where the number of specimens is listed both chelae were analyzed, thus providing two samples per specimen. In cases where obvious abnormalities were present, the chela in question was not used. The trichobothrial patterns represented in Figs. 2-25 are not from particular specimens but rather represent the "ideal" pattern for that species. Fig. 1 illustrates the exact method of measurement for obtaining the raw data used in the ratio calculations. The frequency polygons presented in Figs. 29-36 are based on counts versus percentage of occurrence, and therefore, one should bear in mind the unequal sample sizes that were used in their construction.

TRICHOBOTHRIA NOMENCLATURE OF *HADRURUS*

Probably the most difficult task encountered during this study was constructing a useful trichobothria nomenclature for the very unusual patterns found in *Hadrurus* species. It was important that this scheme provide the most logical system to facilitate phylogenetic studies of the genus as well as provide as little deviation from the basic nomenclature established by Vachon (1973). As it turned out all species had to be studied before a somewhat reasonable and consistent nomenclature could be established, even though some of the designations still remain somewhat arbitrary. Species with the most basic pattern, and consequently the simplest, were used to establish designations for more complicated patterns of closely related species.

Hadrurus conforms to Vachon's third pattern (designated as type C). All 26 designated trichobothria of the chela can be accounted for. The difficulty with *Hadrurus* is that numerous accessory trichobothria are present on the ventral aspect of the chela, and in many species, found on the internal and external aspects as well. The presence of internal accessory trichobothria is very unusual and *Hadrurus* species can have as many as

seven. Vachon (1973) reported only two other species that had internal accessory trichobothria, *Teuthraustes amazonicus* (Vachon, Fig. 186) and *Pandinus hawckeri* (Fig. 118). Vachon designated each internal accessory trichobothrium separately, but due to the larger number and variability found on *Hadrurus* I have decided to refer to them collectively as internal accessory trichobothria. Gonzalez (1972 and 1973) had designated the internal accessory trichobothria for two species of *Broteas*, but this appears to be more of a matter of interpretation and the assignment of individual nomenclature than the actual presence of a new trichobothrium. In his interpretation a ventral trichobothrium is deleted and a new one is designated as internal.

Hadrurus species have an abundance of ventral trichobothria. Obviously some of these trichobothria are more appropriately termed accessory, but due to the great numbers that can be present it is not practical to try to isolate the four basic ventral trichobothria in order to assign individual designations. It appears likely that the internal accessory trichobothria are a derivation of the ventral accessory trichobothria, and hence represent an exaggerated development of this condition. In line with this it also seems reasonable to suspect that the external accessory trichobothria present in some *Hadrurus* species may also be a derivation of the ventral accessory condition. It is interesting to note here that the two species with the most external accessory trichobothria, *H. gertschi*, new species and *H. pinteri* Stahnke, also have the most ventral trichobothria.

Trichobothria *Db*, *Dt*, the external basal series, *Eb1-Eb3* and *Esb*, and the dorsal series *db-dt* are easy to isolate on all eight species. On species where external accessory trichobothria were absent, *Est* was readily distinguishable, but on species where one or more external accessory trichobothria were present, the determination became somewhat arbitrary. Trichobothrium *Et5* is situated on the base of the fixed finger on all species of *Hadrurus*, an unusual position for scorpions conforming to Type C. This determination was made in part due to the determination of *Et4*, which is a little reduced in size from the other surrounding trichobothria. The reduced condition of *Et4* is common for species of the Type C pattern. The determination of *Et5* helped the designation of the external series of the fixed finger, *eb-et*. The designation of the *eb-et* series was straightforward for all species except one. *H. pinteri* has the very unusual characteristic of having an additional trichobothrim in the *eb-et* series. It is situated between trichobothria *eb* and *Et5* (Fig. 14). I have decided, however, based partly on the consistency of the *eb-et* series in the other seven species, to consider this trichobothrium as an unusual development of the external accessory trichobothria. It must be remembered that *Et5* has migrated to the fixed finger in the genus, and therefore, it isn't too unreasonable to consider trichobothrium *Ea* as a derivation of this development. The only other alternative is to designate it as a new trichobothria in the *eb-et* series, an interpretation that deviates more from Vachon's original scheme. Trichobothria *Et1* and *Et4* are readily distinguishable as are *Et2* and *Et3* for those species lacking external accessory trichobothria. In species with external accessory trichobothria, *Et2*, *Et3*, and *Est* determinations were difficult, especially *Est*. Probably the most simple approach would be to designate the external accessory as a continuous group from the median to suprabasal aspects of the palm, assigning *Et2*, *Et3*, and *Est* to the remaining more distal trichobothria. However, already we have deviated from this scheme with *H. pinteri* and, based on a comparative analysis of other related species that do not have external accessory trichobothria, it appears that the scheme does not represent true designations. Therefore, I have decided to designate external accessory trichobothria interspersed among the standard trichobothria.

Based on the positions of *ib* and *it* on *H. aztecus* Pocock and *H. gertschi*, new species the determination of these trichobothria for the other six species was straightforward. In this case the internal accessory trichobothria form a continuous group. It is interesting to note here that for those species whose internal accessory trichobothria extend well onto the palm, these trichobothria are somewhat reduced in size. In some specimens these trichobothria are reduced considerably, making determination as trichobothria quite difficult.

TAXONOMY

One of the most interesting aspects of this study was to attempt to reconstruct the relationship of the species of *Hadrurus* based entirely on the chela trichobothrial pattern. Results of this are presented in the *Hadrurus* key. I recognize two groups based entirely on the presence or absence of internal accessory trichobothria. Two species, *H. aztecus* and *H. gertschi*, new species lack internal accessory trichobothria. Due to this characteristic plus their close geographical proximity and likewise distant range from the other species, I have placed them in the "aztecus" group. However, since the two species have little in common except for the lack of internal accessory trichobothria, I have placed them in separate subgroups, the "aztecus" subgroup and the "gertschi" subgroup. The other group, which I call the "hirsutus" group, has at least two internal accessory trichobothria and sometimes as many as seven. Within this group I recognize two subgroups based entirely on the presence or absence of external accessory trichobothria. The first subgroup, which has one to four external accessory trichobothria, is called the "hirsutus" subgroup and contains species *H. hirsutus* (Wood), *H. concolorous* Stahnke, and *H. pinteri*. The other subgroup, called the "arizonensis" subgroup, does not have external accessory trichobothria and contains *H. arizonensis* Ewing, *H. spadix* Stahnke, and *H. obscurus* Williams.

As the key implies, I could not satisfactorily separate *H. hirsutus* from *H. concolorous* and *H. spadix* from *H. obscurus* using the trichobothrial patterns of the chelae. It appears that these two sets of species may only be subspecific, if one chooses to use only trichobothria. However, other characters must also be considered before making this conclusion.

In coming up with differentiae for the species, only the presence or absence of accessory trichobothria were considered to be of primary importance. Positional differences in the trichobothria were seldom relied upon, and were avoided entirely in most cases.

What must be pointed out here is that the proposed species relationship presented here is essentially the same relationship suggested by Williams (1970b, pp. 31-32) which was based on a different set of structures.

KEY TO *HADRURUS* SPECIES BASED ON TRICHOBOTHRIAL CHARACTERS OF CHELA

1a. Internal accessory trichobothria lacking; trichobothria *ib* and *it* situated basally (Figs. 5, 9) . . . . . ("aztecus" group) 2

1b. 2-7 internal accessory trichobothria present; trichobothria *ib* and *it* situated suprabasally (Figs. 13, 17, 21, 25, 28) . . . . . ("hirsutus" group) 3

2a(1a). External accessory trichobothria lacking on palm (Fig. 2); 17-19 (18) ventral trichobothria on palm, essentially formed in single row (except for distal 1/4) (Fig. 4) . . . . . .("aztecus" subgroup) *H. aztecus* Pocock

2b. 3-4 (4) external accessory trichobothria on palm (Fig. 6); 20-25 (21) ventral trichobothria on palm, forming double row on distal 3/4 (Fig. 8) . . . . . ("gertschi" subgroup) *H. gertschi* new species

3a(1b). 1-4 external accessory trichobothria present (Figs. 10, 14, 26-27) . . . . . ("hirsutus" subgroup) 4

3b. External accessory trichobothria lacking (Figs. 18, 22) . . . . . ("arizonensis" subgroup) 5

4a(3a). 1-2 (1) external accessory trichobothria on palm, none on the fixed finger (Figs. 10, 26); 3-5 (4) internal accessory trichobothria present (Fig. 13); 15-20 (16-18) ventral trichobothria on palm, essentially formed in a single row (Fig. 12) . . . . . *H. hirsutus* (Wood)/*H. concolorous* Stahnke

4b. 3-4 (3) external accessory trichobothria with one situated on external aspect of fixed finger (Figs. 14, 27); 5-6 (6) internal accessory trichobothria present (Fig. 17); 22-27 (25) ventral trichobothria on palm, forming a doubled row on distal 1/3 (Fig. 16) . . . . . *H. pinteri* Stahnke

5a(3b). 4-7 (5-6) internal accessory trichobothria present (Fig. 21); 16-22 (19-20) ventral trichobothria on palm (Fig. 20); trichobothrium *Est* situated medially (Fig. 18) . . . . . .*H. arizonensis* Ewing

5b. 2-4 (2-3) internal accessory trichobothria present (Figs. 25, 28); 13-17 (15) ventral trichobothria on palm (Fig. 24); trichobothrium *Est* situated subterminally (Fig. 22) . . . . . .*H. spadix* Stahnke/*H. obscurus* Williams

Hadrurus aztecus Pocock, 1902
(Figs. 2-5,38-39, and 41)

The chela trichobothrial pattern of *H. aztecus* is the most basic of all species, having accessory trichobothria only on the ventral aspect. Indicative of this species and also of the other member of its group, *H. gertschi*, new species is the absence of internal accessory trichobothria. Also somewhat noticeable are the proximally situated trichobothria *ib* and *it*. On the six species of the "hirsutus" group these trichobothria are situated suprabasally.

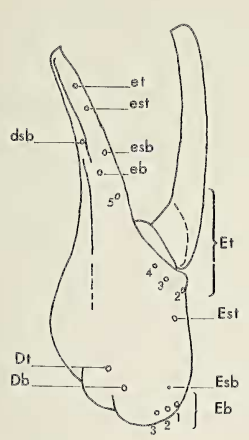
Hadrurus gertschi new species
(Figs. 6-9, 37, and 40)

The absence of the internal accessory trichobothria on this species implies that *H. aztecus* is its closest relative, but the similarity disappears at this point. *H. gertschi*, new

Figs. 2-5.–*Hadrurus aztecus*, trichobothrial pattern of chela: 2, External view; 3, Dorsal view; 4, Ventral view; 5, Internal view. E and e, external; D and d, dorsal; V, ventral; i, internal; b, basal; t, terminal; sb, st, suprabasal and subterminal; and a, accessory.

Figs. 6-9.–*Hadrurus gertschi*, trichobothrial pattern of chela: 6, External view; 7, Dorsal view; 8, Ventral view; 9, Internal view. See Figs. 2-5 for definition of terms.

Figs. 10-13.–*Hadrurus hirsutus/H. concolorous*, trichobothrial pattern of chela: 10, External view; 11, Dorsal view; 12, Ventral view; 13, Internal view. See Figs. 2-5 for definiton of terms.



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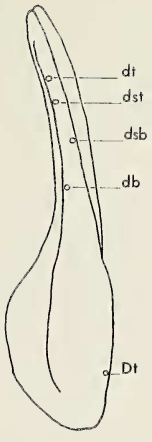

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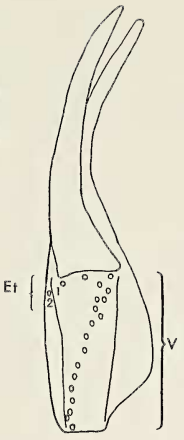

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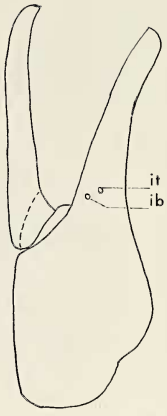

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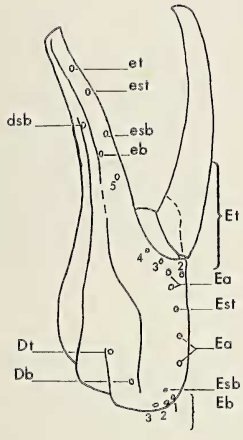

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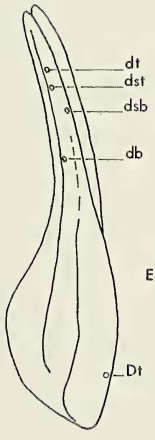

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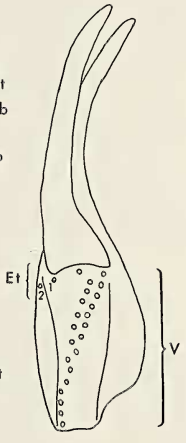

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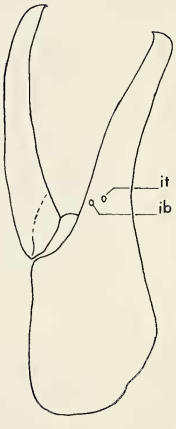

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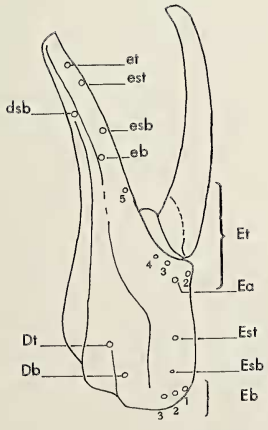

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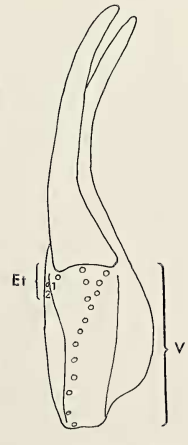

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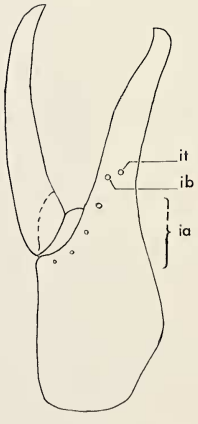

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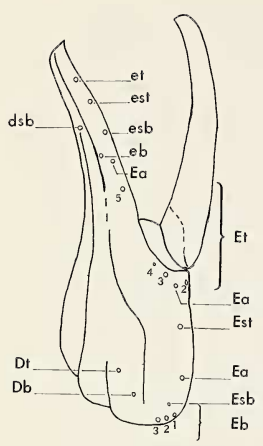

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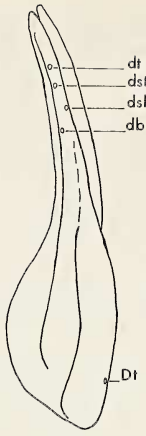

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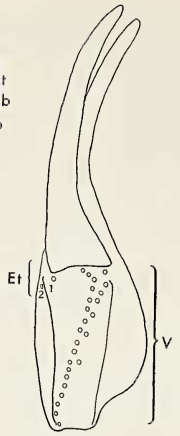

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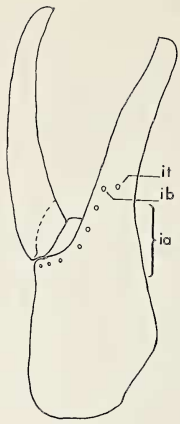

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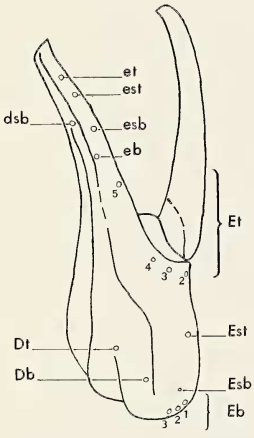

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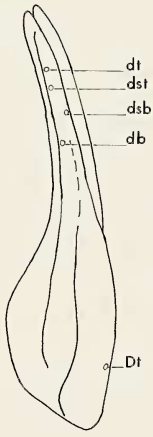

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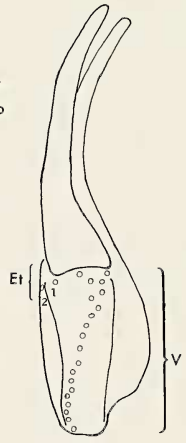

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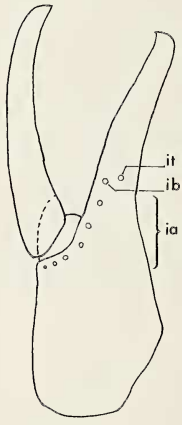

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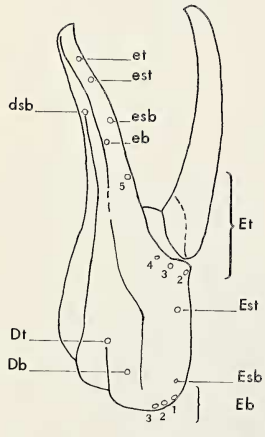

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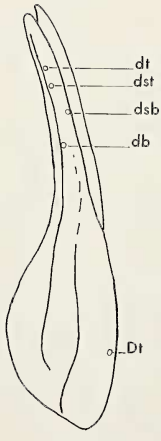

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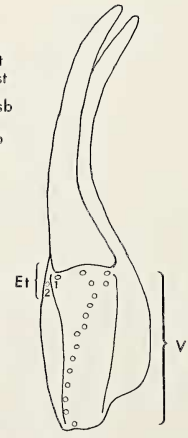

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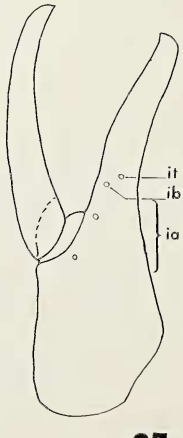

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species usually has three more ventral trichobothria than *H. aztecus* where they are formed in a doubled row for approximately half of its length. This species has more external accessory trichobothria than any of the other species with four as predominant. These trichobothria are limited to the palm where they are interspersed with the other external trichobothria. Trichobothrium *Est* was determined by using *H. aztecus* as a source of comparison.

Hadrurus hirsutus (Wood), 1863
(Figs. 10-13, and 26)

This species has a somewhat complex pattern where accessory trichobothria are present on both the internal and external aspects. It almost always has four internal accessory and usually one external accessory trichobothrium (rarely two, Fig. 26). The ventral trichobothria are somewhat small in number with only *H. spadix* and *H. obscurus* generally having less. The determination of *Est* is somewhat arbitrary.

Hadrurus concolorous Stahnke, 1969
(Figs. 10-13, and 26)

The pattern of this species is essentially identical to that of *H. hirsutus*. Probably the only difference is that this species is usually found with two more ventral trichobothria. However this difference isn't that more significant than that which separates *H. arizonensis arizonensis* and *H. a. pallidus*. The relationship of *H. concolorous* and *H. hirsutus* is quite interesting. Southern populations of this species has coloration approximating that of *H. hirsutus*. Probably the key differences between the two is the aculear glands found on the mature males of *H. concolorous* and pectinal tooth counts. Trichobothrial patterns would seem to imply that *H. concolorous* is only subspecific to *H. hirsutus*.

Hadrurus pinteri Stahnke, 1969
(Figs. 14-17, and 27)

This species definitely has the most complex trichobothrial pattern, with multiple accessory trichobothria present on the internal and external aspects. Most specimens examined had six internal accessory trichobothria, a count only exceeded by *H. arizonensis pallidus* which occasionally reaches seven. *H. pinteri* also has the most ventral trichobothria with a range and mean of 22-27 (24.64). These trichobothria, as in *H. gertschi*, new species are formed in a rough doubled row for approximately the distal third. The most unusual feature of this species pattern is the occurrence of an extra trichobothrium on the fixed finger, situated between *eb* and *Et5*. This trichobothrium has been designated as external accessory based on reasons given earlier in this paper. On the external aspect of the palm are found usually two accessory trichobothria, but three are not unusual (see Fig. 27).

Hadrurus arizonensis Ewing, 1928
(Figs. 18-21)

Species of this subgroup approach the simple pattern exhibited by *H. aztecus*. This

Figs. 14-17.–*Hadrurus pinteri*, trichobothrial pattern of chela: 14, External view; 15, Dorsal view; 16, Ventral view; 17, Internal view. See Figs. 2-5 for definition of terms.

Figs. 18-21.–*Hadrurus arizonensis*, trichobothrial pattern of chela: 18, External view; 19, Dorsal view; 20, Ventral view; 21, Internal view. See Figs. 2-5 for definition of terms.

Figs. 22-25.–*Hadrurus spadix/H. obscurus*, trichobothrial pattern of chela: 22, External view; 23, Dorsal view; 24, Ventral view; 25, Internal view. See Figs. 2-5 for definition of terms.

species, however, has numerous internal accessory with a range and mean of 4-7 (5.54). It is interesting to note that variations in this count were detectable between subspecies, where *H. a. pallidus* had a tendency to have one more trichobothrium than *H. a. arizonensis*. Furthermore, examples from the southern range of *H. a. arizonensis* (Guaymas, Sonora) did not exceed five (based on eight specimens). *H. a. austrinus* appeared to have only four, but due to the limited samples available one cannot infer too much from this. There seems to be a tendency of the southern examples of this species to have less internal accessory and ventral trichobothria. External accessory trichobothria are not found on this species. Trichobothrium *Est* is situated medially but individual specimens were somewhat variable in this character (see Table 3).

Hadrurus spadix Stahnke, 1940
(Figs. 22-25)

This species has a very simple pattern, having the smallest overall number of trichobothria on the chelae. *H. spadix*, along with *H. obscurus*, has the fewest number of ventral trichobothria, with a range and mean of 13-17 (15.04). This species also has the fewest internal accessory trichobothria, usually found with two and occasionally three. Trichobothrium *Est* is usually situated a little forward of the middle of the palm but significant variability is present (Table 3).

Hadrurus obscurus Williams, 1970
(Figs. 22-25, and 28)

H. obscurus patterns are essentially identical to that of *H. spadix*. The major difference encountered within the samples was the occurrence of an additional internal accessory trichobothrium (Fig. 28). The number of ventral trichobothria were also essentially identical to that of *H. spadix*. In addition the placement of *Est*, though quite variable as with the other species, was also a little in front of the middle, providing the same ratio as that found in *H. spadix*. It was noticed early in the course of this study that *esb* and *eb* were relatively closer with respect to *Et5* on *H. obscurus* than on the other species. Therefore, the second ratio in Table 3 was included. Trichobothrial patterns certainly seem to imply that *H. obscurus* is only subspecific to *H. spadix*, not exhibiting any significant differences that are not also found in the subspecies of *H. arizonensis*. It is best, however, to wait for more extensive collecting in the Mohave Desert before making a definite decision. One would suspect that color intergrades will be found.

Hadrurus gertschi, new species
(Figs. 6-9, 37, 40)

Hadrurus aztecus Hoffmann, 1931, pp. 340-346 (part). Stahnke, 1945, pp. 8-9 (part), Stahnke, 1969, p. 59 (part). Williams, 1970, pp. 9-11 (part). Stahnke, 1971, pp. 121-131 (part).

Diagnosis—Large dark species, distinguished by following characters: Tergites and carapace dark-brown, cauda and pedipalps orange. Interocular area of carapace slightly lighter than posterior aspects but not in contrasting manner. Inferior keels of cauda outlined with heavy dark-red lines. Interocular area of carapace smooth and polished on female; with slight granulation on male. Dorsal aspects of cauda with very little setation. Aculear glands absent on mature males. Pectinal tooth counts, 31-33 male, 26-29 female. Trichobothrial pattern with distinguishing features as follows: Internal accessory trichobothria of chelae absent, internal aspect found only with *ib* and *it* which are

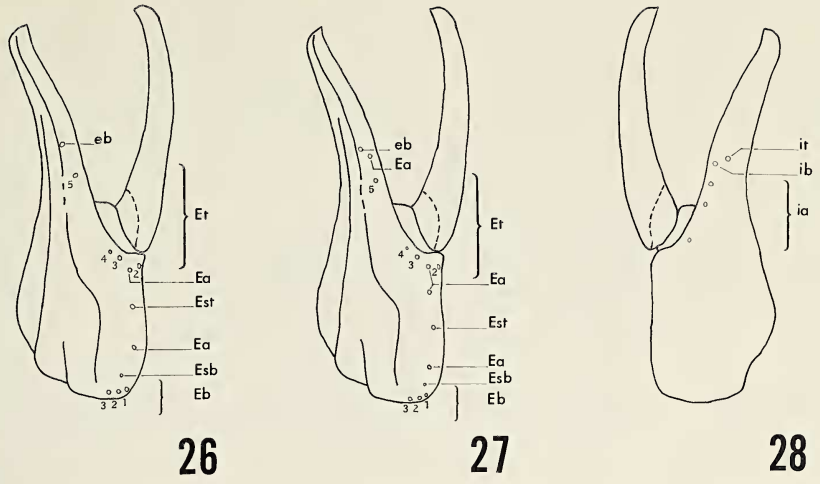


Fig. 26.–*Hadrurus hirsutus*/*H. concolorous*, partial trichobothrial pattern of chela showing two external accessory trichobothria.

Fig. 27.–*Hadrurus pinteri*, partial trichobothrial pattern of chela showing four external accessory trichobothria.

Fig. 28.–*Hadrurus obscurus*, trichobothrial pattern of internal view of chela, which compares with Fig. 25.

proximally situated; 3-4 (4) external accessory trichobothria on chelal palm; 20-25 (21) ventral trichobothria on palm, forming doubled row on distal one-half to three-quarters. Closest relative *H. aztecus* Pocock, based on absence of internal accessory trichobothria on chelae, absence of heavy setation on dorsal aspect of cauda, and close geographical proximity. Table 4 provides differentiating characters.

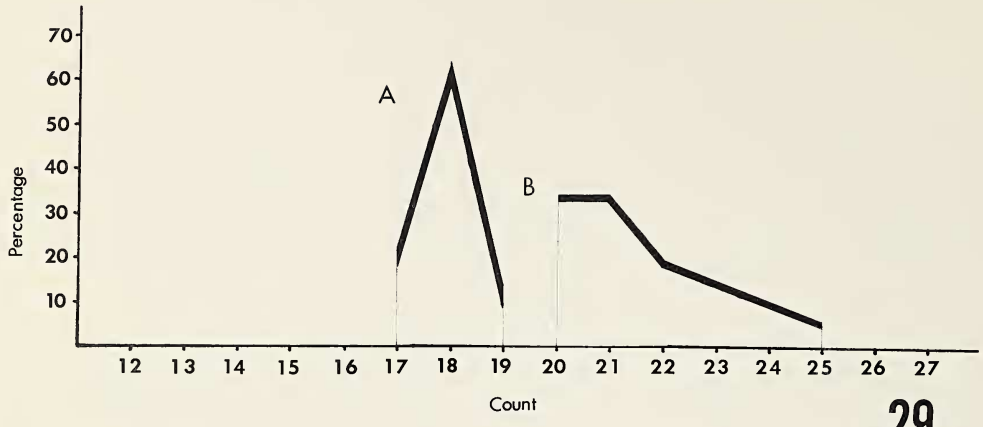
Etymology–This species is dedicated to the eminent arachnologist Willis J. Gertsch, Curator Emeritus, American Museum of Natural History, whose contributions to scorpion systematics have given inspiration to many others.

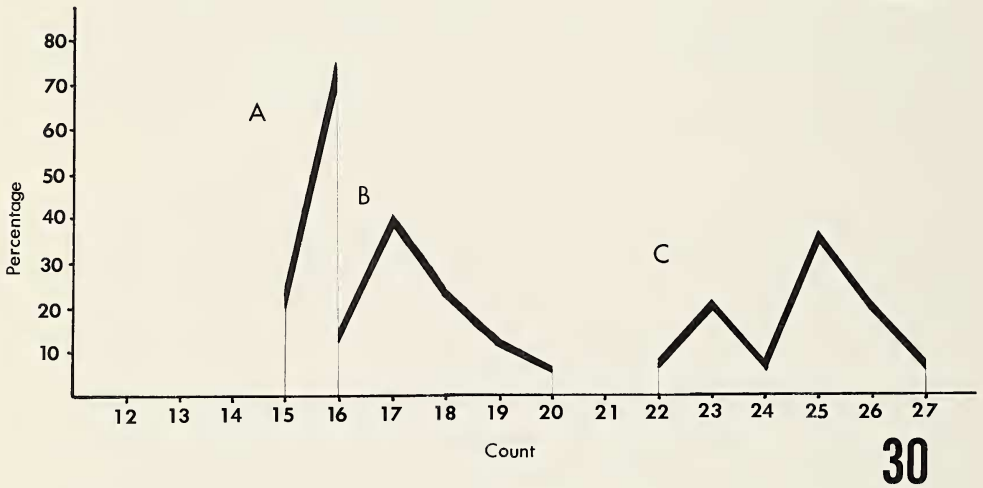
Holotype–Male (Fig. 37). Coloration: Tergites and carapace dark brown; cauda and pedipalps dark orange, walking legs yellow. Interocular area of carapace slightly lighter than remaining area, but not in contrasting manner. Carinae of pedipalpal femur, tibia, and inner, inner accessory, outer, and inner ventral carinae of chelal palm outlined with dark-red pigmentation. Chelal fingers same color as palm. Keels of cauda outlined with light to dark-red lines, heaviest on inferior keels which are solid (with exception of unpigmented inferior median keels of segment I). Ventral face of fifth caudal segment with dark-brown pattern, essentially solid on posterior aspect, becoming somewhat mottled on anterior half. Granules of ventral aspect of telson vesicle light brown. Aculeus dark-brown to black.

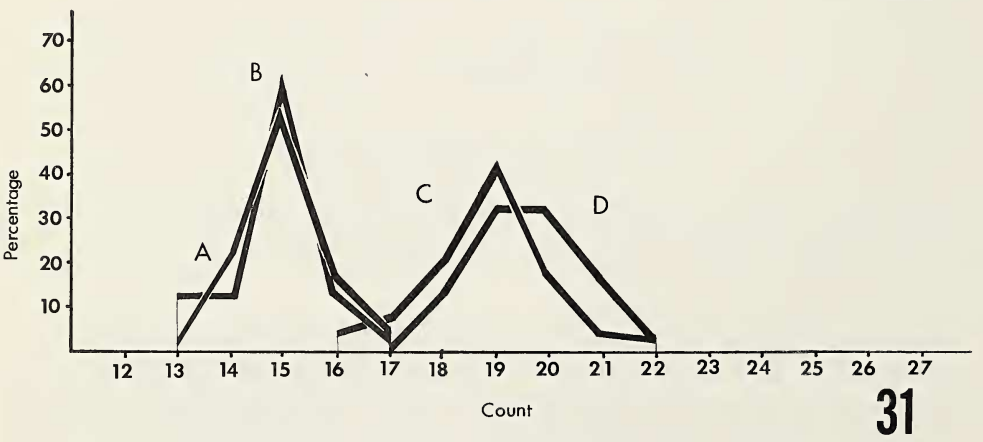
Structure–Measurements of holotype male and allotype female given in Table 5.

Carapace. Anterior edge conspicuously convexed, typical of genus. Approximately 24 setae on or near anterior edge. Interocular area essentially smooth except for slight traces of polished granulation; posterior aspects with dense granulation. Median tubercle situated at middle; approximately one-fifth width of carapace at that point.

Preabdomen. Tergites generally glossy with sharp granules on posterior lateral aspects. Keels of tergite VII essentially obliterated by heavy granulation. Sternites smooth with long slit-like stigmata. One pair of weak, smooth keels on last sternite.







Figs. 29-31.—Frequency polygons of ventral trichobothrium counts: 29, A, *Hadrurus aztecus*; and B, *H. gertschi*; 30, A, *H. hirsutus*; B, *H. concolorous*; and C, *H. pinteri*; 31, A, *H. spadix*; B, *H. obscurus*; C, *H. arizonensis arizonensis*; and D, *H. a. pallidus*.

Table 2.–Trichobothria count statistics of chela.

	Internal Accessory, Range (Mean) (Standard Deviation)	External Accessory., Range (Mean) (Standard Deviation)	Ventral, Range (Mean) (Standard Deviation)
H. aztecus	0	0	17-19(17.91) (±0.60)
H. gertschi	0	3-4(3.64) (±0.48)	20-25(21.14) (±1.30)
H. hirsutus	4-5(4.06) (±0.24)	1-2(1.06) (±0.24)	15-16(15.75) (±0.43)
H. concolorous	3-5(4.09) (±0.52)	1-2(1.09) (±0.29)	16-20(17.53) (±1.09)
H. hirsutus/ *H. concolorous*	3-5(4.08) (±0.45)	1-2(1.08) (±0.28)	15-20(16.94) (±1.25)
H. pinteri	5-6(5.69) (±0.46)	3-4(3.43) (±0.49)	22-27(24.64) (±1.39)
H. arizonensis	4-7(5.54) (±0.60)	0	16-22(19.12) (±1.18)
H. a. arizonensis (all populations)	4-6(5.44) (±0.56)	0	16-22(18.88) (±1.19)
H. a. arizonensis (Guaymas population)	4-5(4.88) (±0.33)	0	16-19(17.63) (±0.93)
H. a. arizonensis (other populations)	4-6(5.54) (±0.54)	0	16-22(19.08) (±1.10)
H. a. pallidus	5-7(5.78) (±0.51)	0	17-22(19.59) (±1.05)
H. a. austrinus	4-5(4.25)	0	18-19(18.67)
H. spadix	2-3(2.17) (±0.38)	0	13-17(15.04) (±0.78)
H. obscurus	2-4(2.94) (±0.33)	0	13-17(14.89) (±0.90)
H. spadix/ *H. obscurus*	2-4(2.35) (±0.49)	0	13-17(15.01) (±0.81)

Cauda. Segments I-IV: First caudal segment wider than long. Dorsal and dorsal lateral keels crenulate. Lateral keel complete and crenulate on segment I, complete and crenulate on posterior half of II, crenulate on posterior third of III, and unevenly granulate on posterior half of IV. Inferior lateral and median keels smooth. Intercarinal spaces granulate on dorsal aspect. Inferior median keels equipped with 3-4-4-4 pairs of setae, but lacking setae between these keels. Dorsal aspects of segments with little setation. Segment V: Dorsal keels crenulate; lateral keels serrate on anterior third. Inferior lateral and median keels highly serrate. Weak rounded granules on lateral and dorsal aspects of segment; serrate granules on venter. Anal keel serrate with 14 granules.

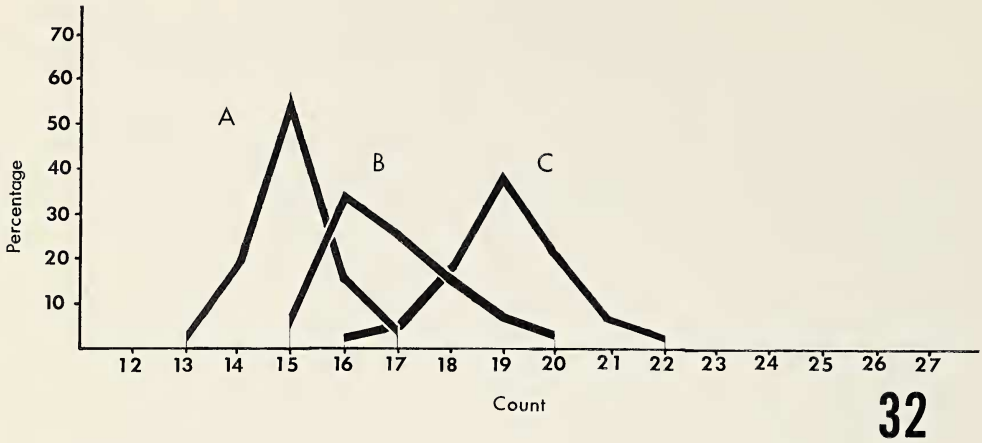
Telson. Typical of genus with bulbous vesicle and highly curved aculeus. Conspicuous granules on base of ventral aspect of vesicle with rounded granules on remainder of ventral face and lateral areas. Ventral aspect of vesicle and base of aculeus densely covered with long setae. Mature holotype male not equipped with aculear glands.

Pectines. Structured as typical *Hadrurus*. Pectinal tooth count 31/31; approximately 14 irregular middle lamellae. Two to three short red setae on each fulcrum; numerous setae on middle and anterior lamellae as well as on most distal tooth. Basal piece split on anterior half; length to width ratio 2/3.

Genital Operculum. Essentially separated on entirety; each sclerite equipped with four to five short red setae on posterior half. Genital papillae not present.

Chelicerae. Typical dentition of genus with large robust denticle on proximal half of ventral edge of movable finger; other dentition standard for family. Serrulae lacking on distal aspect of movable finger ventral edge.

Pedipalps. Large appendages, with conspicuously long setae on internal faces of femur and tibia. Femoral carinae crenulate to serrate except for rounded ventral external carina. Dorsal, internal, and external faces smooth, ventral face with line of granules on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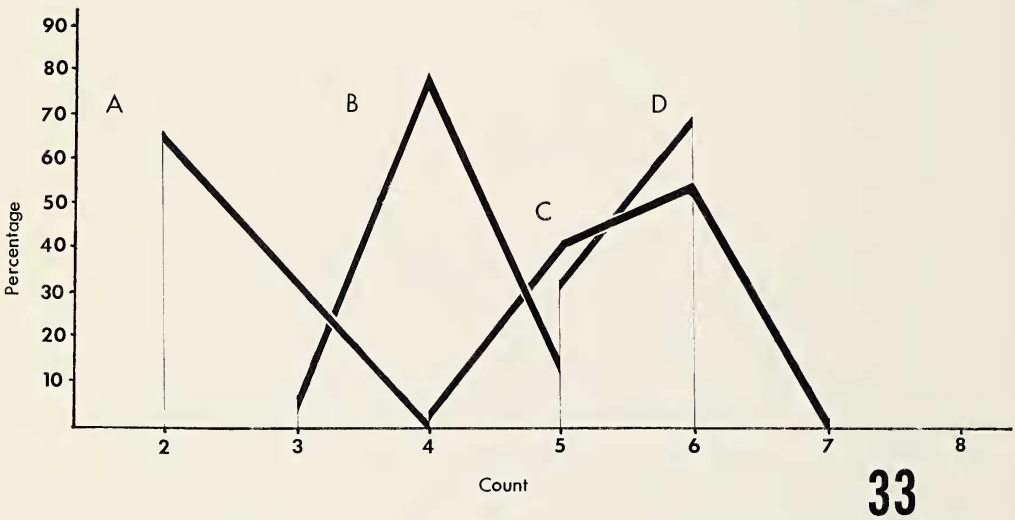
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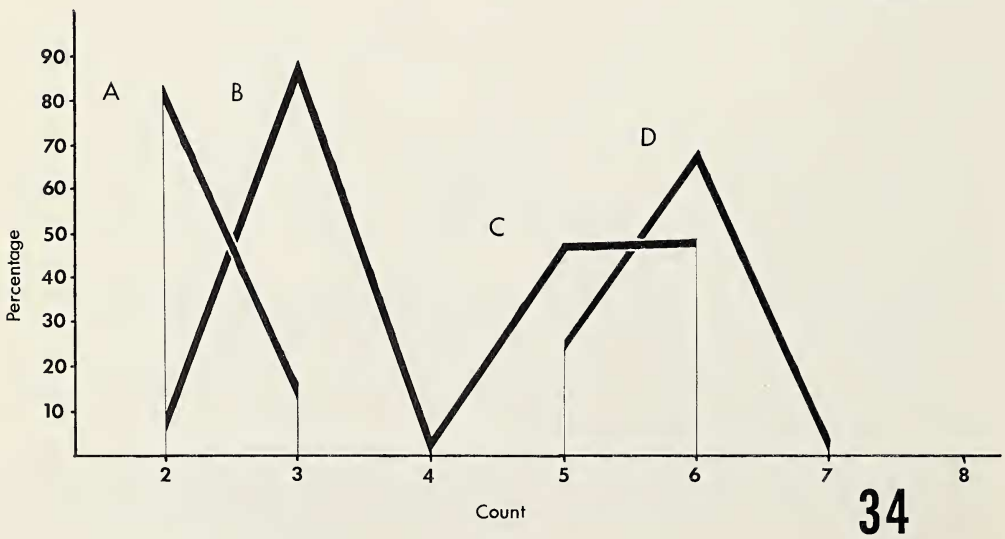
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2 3 4 5 6 7 8
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34

Table 3.–Trichobothria ratio statistics of chela (see Fig. 1).

	b (distance from *Est* to terminal aspect of palm) / *a* (palm length), Range (Mean) (Standard Deviation)	*d* (distance from *eb* to *esb*) / *c* (distance from *Et5* to *esb*), Range (Mean) (Standard Deviation)	Number of Specimens Sampled
H. arizonensis	0.388-0.563(0.485) (±0.041)	0.274-0.583(0.401) (±0.056)	49
H. a. arizonensis	0.394-0.559(0.496) (±0.036)	0.300-0.500(0.412) (±0.047)	25
H. a. pallidus	0.388-0.562(0.470) (±0.041)	0.274-0.583(0.383) (±0.059)	23
H. a. austrinus	0.543-0.563(0.553)	0.485-0.515(0.500)	1
H. spadix	0.321-0.578(0.409) (±0.053)	0.290-0.515(0.417) (±0.048)	21
H. obscurus	0.343-0.456(0.401) (±0.032)	0.197-0.444(0.336) (±0.060)	10
H. spadix/H. obscurus	0.321-0.578(0.406) (±0.048)	0.197-0.515(0.391) (±0.064)	31

proximal aspect. Dorsal internal carina of tibia crenulate; dorsal external smooth; ventral internal with widely separated serrate granules; ventral external rough to smooth. Ventral, internal, and external faces smooth; dorsal face with scattered granulation. Chelae with seven carinae structured as follows (Fig. 40): Outer carina doubled and granulate; inner ventral rough to smooth; superior very rounded, almost obsolete; inner and inner accessory strongly developed, granulate on proximal aspects; inner secondary and inferior very round, almost obsolete. Both movable and fixed fingers equipped with nine short nonoverlapping rows of principal denticles. Nine and eight supernumerary denticles present on movable and fixed fingers respectively. Trichobothrial pattern of chelae follows form illustrated in Figs. 6-9. Male holotype chelae with 47 trichobothria, comprised of 26 standard trichobothria, four external accessory trichobothria, and 17 accessory ventral trichobothria. Trichobothria *ib* and *it* proximally situated. Tibia with 74/70 (left/right) trichobothria; 28/24 ventral, 43 external, two dorsal, and one internal. Femur with standard three trichobothria.

Walking Legs. Tarsomere II densely equipped with long setae; ventral edge with single row of stout spines. Pedal spurs with spineletts.

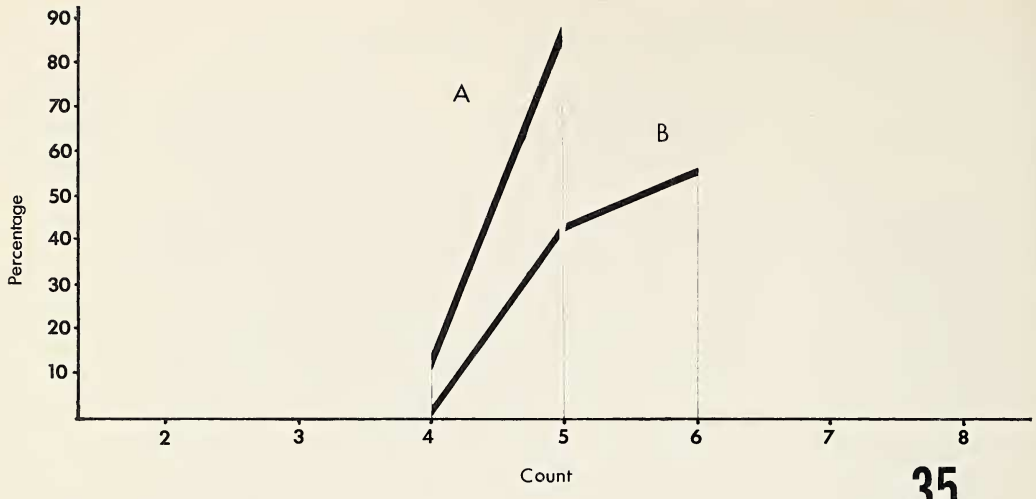
Allotype–Female. Larger than male in overall size. Interocular area of carapace completely smooth, lacking subtle granulation of holotype. Tergites with less granulation on posterior aspects; heavier granulation on vesicle of telson. Genital operculum essentially separated on entirety, as in holotype. Pectines smaller, with 27 teeth and 15/14 middle lamellae.

Paratype Variation–Little or no significant variation detected in five paratypes. Coloration of subadult male from Azcala, Guerrero more mottled than holotype on ventral aspect of fifth caudal segment. Pectinal tooth counts for seven specimens as follows: 31-33, male; 26-29, female, based on two and five specimens respecitvely.

Type Data–Male holotype and female allotype from Azcala, Guerrero, Mexico, 21 June 1969 (Hector Perez R.). Holotype and allotype permanently deposited in California Academy of Sciences, where they have been assigned type number 12186.

Fig. 32.–Frequency polygon of ventral trichobothrium counts. A, *Hadrurus spadix/H. obscurus*; B, *H. hirsutus/H. concolorous*; and C, *H. arizonensis.*

Figs. 33-34.–Frequency polygons of internal accessory trichobothrium counts: 33, A, *Hadrurus spadix/H. obscurus*; B, *H. hirsutus/H. concolorous*; C, *H. arizonensis*; and D, *H. pinteri*; 34, A, *H. spadix*; B, *H. obscurus*; C, *H. arizonensis arizonensis*; and D, *H. a. pallidus.*



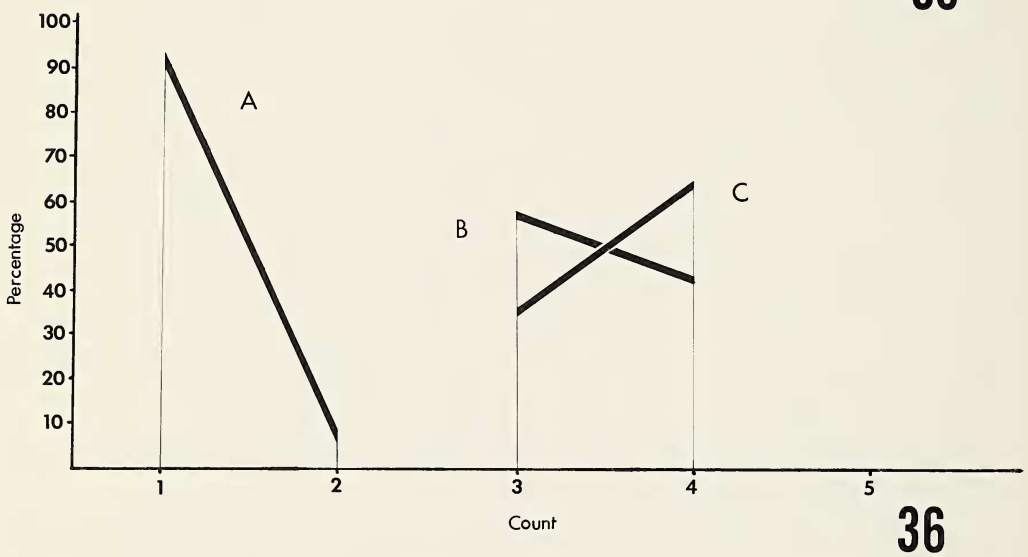


Fig. 35.–Frequency polygon of internal accessory trichobothrium counts. A, *Hadrurus arizonensis arizonensis*, Guaymas population; B, *H. a. arizonensis*, other populations.

Fig. 36.–Frequency polygon of external accessory trichobothrium counts: A, *Hadrurus hirsutus/H. concolorous*; B, *H. pinteri*; and C, *H. gertschi.*

Distribution–All known specimens from state of Guerrero.

Records–Guerrero, Mexico: Azcala, 21 June 1969 (Hector Perez R.), 2 adult females, 1 subadult female, 1 adult male, and 1 subadult male; Iguala, date and collector unknown (from "Hoffmann Collection" in American Museum of Natural History), 1 adult female; Chilpancingo, date and collector unknown (from "Hoffmann Collection" in American Museum of Natural History), 1 adult female.

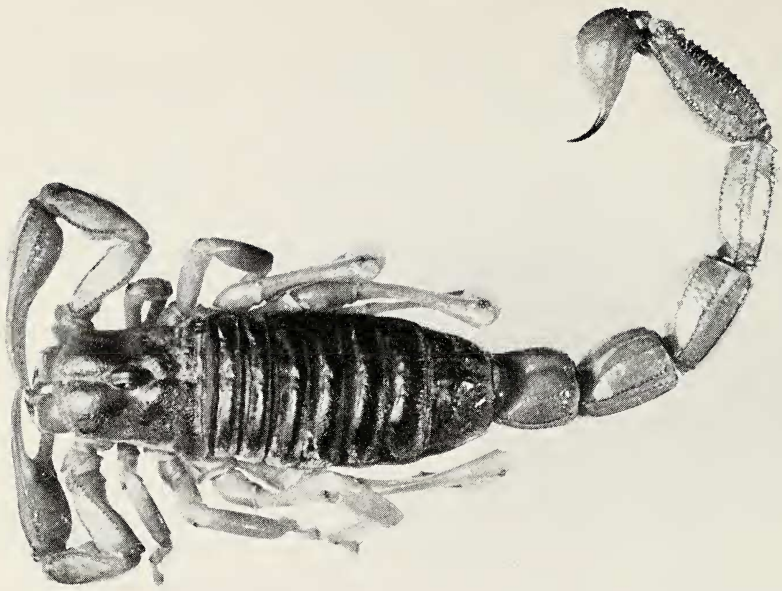
Comments–All specimens of *H. gertschi* that I have had the opportunity to examine have come from the State of Guerrero. One of the females from the AMNH collection was labelled "Hoffmann Collection" but after close comparisons of the measurements and pectinal tooth counts in Hoffmann (1931), I suspect this specimen is the one from Chilpancingo, Guerrero (Hoffmann, p. 343), and therefore have taken the liberty in

Table 4.–Characteristics of *Hadrurus aztecus* Pocock and *H. gertschi*, new species.

	H. aztecus	*H. gertschi*
Coloration of carapace	Dark brown; interocular area light-yellow in definite contrast (Fig. 38)	Dark brown on entirety; interocular area slightly lighter but not in contrast (Fig. 37)
Coloration of chelae	Yellow with light to medium-red fingers (Fig. 39)	Orange, fingers same color as palm (Fig. 40)
Coloration of inferior keels of cauda	Outlined faintly with uneven light-red lines, some discontinuous	Outlined with heavy continuous dark-red lines
Aculear glands of mature male	Conspicuously present (Fig. 41)	Absent
Interocular area of carapace	Covered with large round granules on both male and female	Slight traces of granulation on male; smooth on female
Shape of dorsal aspect of chelal palm	Conspicuously arched, raised considerably above proximal aspect of fixed finger (Fig. 39)	Arched gradually, not raised conspicuously above proximal aspect of fixed finger (Fig. 40)
Inner accessory carina of chelae	Same color as palm, rounded and smooth, with slight granulation on proximal aspect	Red, well developed, granulated on proximal aspect
Number of ventral trichobothria on chelal palm	16-19 (18)	20-25 (21)
Number of external accessory trichobothria on chelal palm	Absent (Fig. 2)	3-4 (4) (Fig. 6)

labelling it as such in Table 5 as well as in the record data. The other two examples from the AMNH turned out to be the actual specimens used by Hoffmann in his Figs. 20-21, a male *H. aztecus* and a large female *H. gertschi*. As of now all specimens of *H. aztecus* so far examined have come from either Puebla or Oaxaca. Obviously, this is not sufficient data to make any definite conclusions as to the geographical ranges of the two species.

Pocock's *H. aztecus* has caused considerable confusion for many years. It was redescribed by Stahnke (1971) from the holotype male. Hoffmann provided an excellent description of *H. aztecus* but unfortunately he had combined two species in his description. In all fairness, it should be pointed out here that Hoffmann had noticed differences between the female specimens from Guerrero and those occurring in Puebla and Oaxaca (Hoffmann, 1931, pp. 340-342, 345). I do believe that, although Hoffmann's work was usually on the conservative side, he would have separated the two species had he had sufficient material, especially with respect to more male specimens from Guerrero. Likewise Williams (1970) had only two specimens to study for his excellent revision of the genus, both being *H. gertschi*. The insufficient material combined with Hoffmann's composite description of the two species left Williams with no other alternative but to identify the specimens as *H. aztecus*. I was extremely fortunate to have collected eleven specimens of *H. aztecus* from the Tehuacan Valley of Puebla. These specimens plus the



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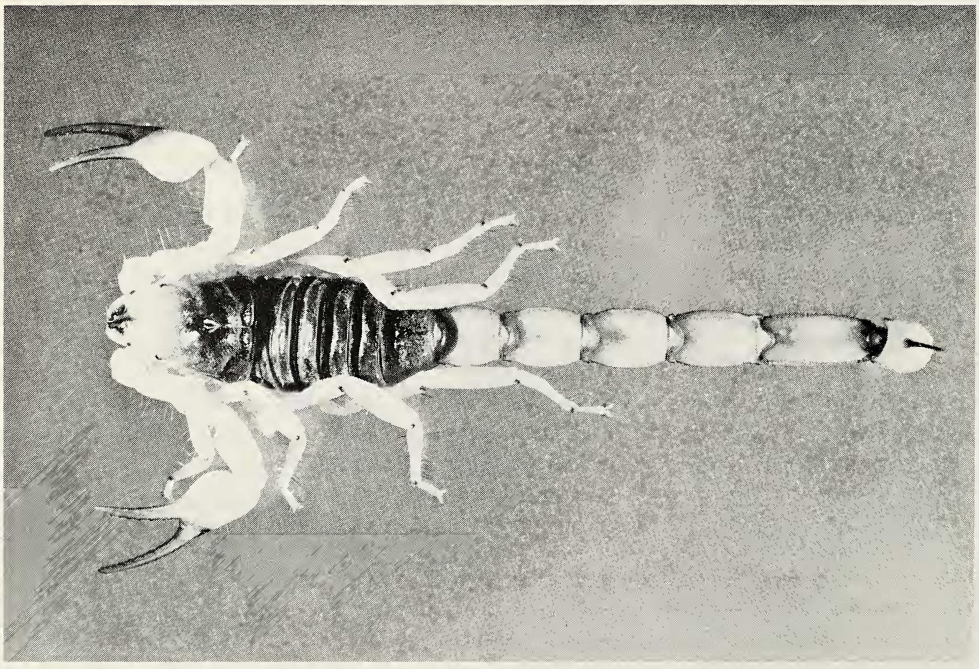

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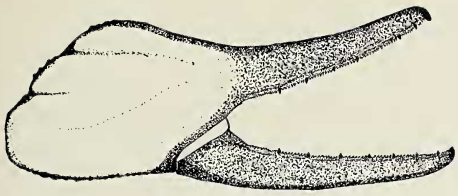

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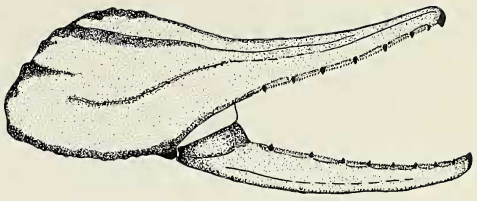

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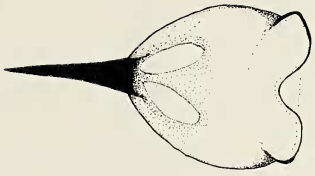

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Fig. 39.–*Hadrurus aztecus*, chela of male, Tehuacan, Puebla.
Fig. 40.–*Hadrurus gertschi*, new species, chela of holotype male.
Fig. 41.–*Hadrurus aztecus*, dorsal view of telson of mature male showing aculear glands.

single male from Oaxaca provided me with a small but adequate sample to sort the two species apart. I have taken this opportunity to provide measurements of *H. aztecus* (Table 6).

I must express my admiration for Pocock's original description of *H. aztecus*. Even at that time he had noticed the unusual shape of the chelal palm compared to that of a California species (Pocock, 1902, Table 2, Figs. 1.e. and 2).

It should be noted here that the twelve examples of *H. aztecus* examined did exhibit faint red pigmentation on the inferior median keels of the cauda. Stahnke (p. 122) stated that this pigmentation is not found on the holotype male. In all probability this pigmentation has faded on the holotype due to the many years of preservation. Also, Stahnke (p. 123) reported: "Exterior surface of manus has about twenty-two trichobothria." This is mentioned here since the two species are separated, in part, by the number of ventral trichobothria present, and Stahnke's statement places the male holotype in the range of *H. gertschi*, not *H. aztecus*. Since a drawing of the actual trichobothrial pattern was not provided, one must only guess as to which trichobothria are actually included in this estimation. In more recent literature Stahnke (1973, p. 123, Fig. 5A) has included trichobothrium *Et1* in the ventral series. It is my decision, therefore, that since the data were presented as an estimate and that its method of determination is not clear, this discrepancy be ignored at this time.

Aculear glands were present on six adult male *H. aztecus* from Tehuacan, Puebla, and also on the single male from Tomellin, Oaxaca. Although little is known about the function of these glands, it is believed that they appear on sexually mature males of those species which have them. Previously Williams (1970a, 1970b) had reported them on *H.*

Fig. 37.–*Hadrurus gertschi* Soleglad, new species, holotype male, dorsal view.
Fig. 38.–*Hadrurus aztecus* Pocock, male, Tehuacan, Puebla, dorsal view.

Table 5.–Measurements in (millimeters) of *Hadrurus gertschi*, new species.

	Azcala, Guerrero, Mexico			Chilpancingo, Guerrero
	Holotype Male	Allotype Female	Paratype Male	Paratype Female
Total length	90.0	99.9	64.9	88.1
Carapace, length	13.6	15.4	10.3	13.0
Width at lateral eyes	9.5	11.2	7.6	8.8
Width at caudal edge	13.3	15.5	10.0	12.5
Preabdomen, length	25.7	33.2	22.6	34.3
Postabdomen, length	50.7	51.3	32.0	40.8
Caudal segment I				
Length	7.7	7.5	4.9	6.3
Width	8.1	8.1	5.25	6.6
Depth	6.5	6.6	4.4	5.5
Caudal segment II				
Length	8.8	8.9	5.7	7.3
Width	7.8	7.8	4.9	6.4
Depth	6.35	6.5	4.3	5.3
Caudal segment III				
Length	9.7	9.6	6.1	7.7
Width	7.6	7.7	4.9	6.3
Depth	6.1	6.4	4.3	5.1
Caudal segment IV				
Length	11.3	11.1	6.9	9.0
Width	7.4	7.6	4.8	6.2
Depth	5.7	6.0	4.1	4.7
Caudal segment V				
Length	13.2	14.2	8.4	10.5
Width	6.6	7.0	4.5	5.7
Depth	5.7	5.7	3.9	4.6
Telson, length	13.1	14.2	8.9	11.0
Vesicle				
Length	8.9	9.7	6.0	6.5
Width	6.4	7.2	4.1	5.2
Depth	5.5	6.0	3.5	4.4
Aculeus, length	4.2	4.5	2.9	4.5
Pedipalp, length	38.6	43.3	28.4	35.9
Femur				
Length	9.0	9.8	6.5	8.0
Depth	3.1	3.7	2.4	3.0
Tibia				
Length	10.7	12.0	7.7	9.9
Depth	3.9	5.2	3.3	4.0
Chela, length	18.9	21.5	14.2	18.0
Palm				
Length	7.3	8.2	5.2	6.9
Width	6.3	7.9	4.2	5.8
Depth	4.8	6.4	3.3	4.5
Fixed finger, length	9.5	11.0	7.6	9.4
Movable finger, length	12.6	14.5	9.3	11.8
Pectines				
Teeth	31/31	27/27	33/33	29/29
Middle lamellae	14/14	15/14	13/14	15/12

Table 6.–Measurements (in millimeters) of *Hadrurus aztecus* Pocock from Tehuacan, Puebla, Mexico.

	Male	Female
Total length	92.2	75.1
Carapace, length	13.6	11.3
Width at lateral eyes	9.2	8.4
Width at caudal edge	14.4	12.0
Preabdomen, length	25.0	22.9
Postabdomen, length	53.6	40.9
Caudal segment I		
Length	7.95	6.15
Width	7.8	6.0
Depth	6.1	5.05
Caudal segment II		
Length	9.35	7.1
Width	7.4	5.65
Depth	6.15	4.9
Caudal segment III		
Length	10.2	7.7
Width	7.5	5.55
Depth	5.95	4.75
Caudal segment IV		
Length	11.8	8.85
Width	7.2	5.4
Depth	5.65	4.45
Caudal segment V		
Length	14.3	11.1
Width	6.8	5.15
Depth	5.5	4.4
Telson, length	13.15	11.2
Vesicle		
Length	9.1	7.6
Width	6.7	5.15
Depth	5.8	4.7
Aculeus, length	4.05	3.6
Pedipalp, length	39.6	32.95
Femur		
Length	9.5	7.6
Depth	3.3	2.8
Tibia		
Length	11.0	9.15
Depth	4.85	3.9
Chela, length	19.1	16.2
Palm		
Length	7.5	6.4
Width	7.5	5.6
Depth	5.6	4.0
Fixed finger, length	9.6	8.0
Movable finger, length	12.7	10.5
Pectines		
Teeth	37/38	31/32
Middle lamellae	14/16	15/15

concolorous and *H. pinteri*. Stahnke reported that the holotype male of *H. aztecus* also was equipped with them. So far only two of what appear to be sexually mature males of

H. gertschi have been reported, the holotype from Azala and the male studied by Williams (a specimen which was not available for this study). Neither of these specimens had any trace of the aculear glands. It should be pointed out here that it is not clear when the glands actually appear on the male but it does seem reasonable to conclude, even based on the sparse samples available, that *H. gertschi* does not have these glands.

Also from the limited data on male specimens of *H. gertschi*, it appears that *H. aztecus* may in general have a larger pectinal tooth count with ranges and means as follows: 33-40 (36.3) for ten male specimens and 29-32 (30.75) for two female specimens. The ranges for *H. gertschi* are 31-33 (32) for two male specimens and 26-29 (27.31) for five females.

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